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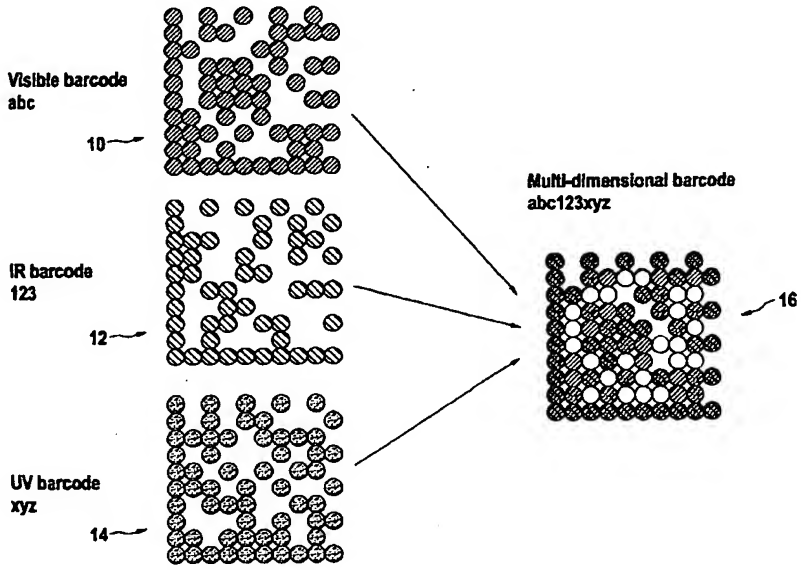
(54) Title: MULTI-DIMENSIONAL BARCODE AND APPARATUS FOR READING A MULTI-DIMENSIONAL BARCODE



(57) Abstract: Two-dimensional barcodes of different colors are printed on top of each other to produce a multi-dimensional barcode with increased information content. One or more of the barcodes may be printed invisible to the naked eye, so that special equipment is needed to decode the information. An apparatus for reading the multi-dimensional barcode has an array of filters or the like for distinguishing the colors, and preferably includes means for information decoding.

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MULTI-DIMENSIONAL BARCODE AND APPARATUS FOR READING A MULTI-DIMENSIONAL BARCODE

BACKGROUND OF THE INVENTION

This invention relates to a product marking and a method of applying and reading a marking. The most common product markings comprise a barcode.

Common barcodes consist of a series of parallel stripes of different widths which are printed on a product or label, and convey coded information about the product. The product code can be read optically, then linked to other information such as pricing, source and stock information.

Prior inventors have developed two-dimensional barcodes which are composed of an array of dots or rectangles, and are read by scanning in two dimensions. Such arrays can have much more information content, but are more susceptible to reading errors and information loss.

Conventional barcodes are monochromatic. One can increase the information content of barcodes by printing them in more than one color. The idea of incorporating a spectral dimension into a barcode to obtain further increased information density is already known. U.S. Patent 5,576,528, for example, discloses producing two-dimensional barcodes by overprinting a colored one-dimensional barcode with another barcode of a different color.

U.S. Patent 5,160,171 and EP 340 898 disclose barcodes which are created by overprinting a color barcode with a transparent printing ink containing infrared absorbers.

U.S. Patent 5,360,235 discloses the general idea of a security marking employing a printing ink having ultraviolet absorbers.

EP 420 613 describes the printing of two kinds of barcodes, one on top of the other.

U.S. Patent 3,684,868 describes the use of materials having reflectivity in the infrared and visible spectral domains in conjunction with differently colored bar codes.

The present invention contemplates adding a spectral, or color, dimension to a two-dimensional barcode symbology, resulting in a substantial enlargement of storage capacity,

so that more data can be printed in a limited space.

The spectral dimension is obtained by using a set of N colorants, each having a particular absorption band which is not covered by any other member of the set. This way, N distinct barcodes, preferably two-dimensional barcodes, can be superposed on top of the other, thus creating said multi-dimension. Layers of luminescent materials may be added as well.

SUMMARY OF THE INVENTION

An object of the invention is to increase the information content of a product marking.

Another object is to improve the security of markings.

These and other objects are attained by a marking which includes at least one two-dimensional code of a first color, comprising a two-dimensional array of marks of said first color arranged to represent information according to an encoding algorithm, and at least one mark or array of marks in a second color, arranged to represent additional information. Preferably, the second array is also a two-dimensional barcode, and the barcodes are preferably in mutual alignment with one another, although a lack of alignment can be compensated for electronically. "In alignment" shall mean a) one mark on top of the other thereby covering the marks below fully or in part; and b) shall mean, marks side by side with different colors printed. We also prefer that the second color be in the invisible spectrum (infrared or ultraviolet). In this context, the term "color" is mainly used synonymous to "spectral absorption" and/or to absorption reflection properties as specified further below.

If the marks are made with an ink, they may be conveniently applied with an ink jet printer.

To read the marks, one can use a video camera associated with a computer which includes software for forming virtual images of the respective codes, and a decoder for interpreting the marks. The various code arrays are distinguished by periodically moving filters of different color, inserted in front of a monochrome camera, or alternatively, by using a corresponding "color" camera.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings,

Figure 1 is a diagram showing the composition of a first barcode embodying the invention;

Figure 2 is a diagram showing the composition of a second embodiment of the invention;

Figure 3 is a schematic diagram of a system for reading a multi-dimensional barcode embodying the present invention; and

Figure 4 is a schematic diagram of a modified system in accordance with figure 3 to read a UV and IR marking of a code.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 shows diagrammatically a product marking comprising three two-dimensional barcodes 10,12,14 of different colors which are printed, one on top of the other, on a product or label, to produce a composite multi-dimensional marking 16 having a spectral dimension. Each of the component codes comprises a two-dimensional array of marks arranged in rows and columns according to a known, if needed secret, encoding algorithm. This algorithm may contain error-checking functions to reduce reading errors, which may occur when the marks have faded or become damaged. The marks need not to be round; the term is meant, in a general sense, to connote colored areas, which may be circles, polygons, or the like, that can be detected by an optical reader.

Each of the inks used to produce each pattern has a distinct optical absorption property, designated hereafter as color (i.e., has a characteristic absorption/ reflection signature which makes it distinguishable from the other inks when read by an optical reader).

The term "color" shall stand for absorption/reflection properties over the whole range of the electromagnetic spectrum, preferably for "light" (visible and invisible) wavelengths in the range of between 100 nm to 1 mm (far UV to far IR range). The inks may be applied by various means, including an ink-jet printer. With this arrangement, it is important that the inks of higher layers be substantially transparent to some of the reflected or emitted light of the lower layers, so that information in the lower layers is not lost. The detected "color" of each ink can be due to effects in the visible, infrared, or ultraviolet spectrum.
In a further embodiment, at least one of the array of marks, preferably a barcode, is magnetic and/or has magneto-optical properties. The latter means that the optical response to incident light depends on the magnetic field applied. The magnetic properties, i.e. whether a mark is magnetic or not, can be detected in a magnetic field.

An advantage of multi-dimensional codes, particularly barcodes having a color dimension, is that they are difficult to recognize and to read with the naked eye, and thus are useful in product security applications, on currency, and on security badges and the like. An additional advantage is that much more information can be stored in a given area than with a single-color two-dimensional code.

While Figure 1 shows the patterns having been applied in alignment, it is not a requirement of this invention that the patterns be aligned as long as the reader is designed to read each pattern regardless of its offset.

Figure 2 shows an alternative form of the invention wherein the layers of information are neither stacked, nor aligned. The information contained in a composite barcode 20 (as shown in Figure 1) is split between the visible array 22 of dots on the left, and an invisible array 24, on the right. The visible array alone cannot be decoded with a standard reader and decoder because the information it contains is incomplete. One must be equipped to read the invisible array, which may have more than one type of invisible pigment requiring a special reader. The information derived from the invisible array 24 completes the information contained in the visible array 22. Both information can be processed in a computer.

As illustrated in Figure 3, each of the multi-dimensional codes can be read by a monochrome video camera 30 connected to a computer 32 which includes a frame grabber interface, and corresponding decoding hardware and software, not shown. A filter tray 34 is

used to switch periodically between the filters 36 corresponding to the different spectral domains of observation, that is, the colors of the codes. The tray 34 is rotated by a step motor 38, which in turn is controlled by the computer 32. This arrangement requires precise mechanical synchronization between the filter tray and the camera.

One could avoid the need for mechanical synchronization by substituting for the motorized filter tray a number of Si-CCD monochrome cameras responsive to the different colors, or a single, multi-color Si-CCD camera, so that the various layers or colors could be read substantially simultaneously. Multicolor CCD's are essentially high definition monochrome CCD chips, superposed with a corresponding color micro-filter plate. For example, four squares of adjacent pixels are combined in this way to form red-green-blue-white super-pixels. Multicolor CCD's have the advantage of intrinsic stability. That is, every pixel is hardware-assigned to a determinate color of a determinate image point.

By developing customer-specific filter plates (e.g., by combining squares of nine adjacent pixels on a high definition CCD device to form corresponding UV-visible-IR multi-color sensitive super-pixels) and corresponding camera driver software, commercial CCD devices and frame grabbers can be easily turned into application-specific devices for product security purposes.

Another alternative to the use of a sequential filter wheel would be that of a liquid crystal tunable filter, not shown. This is a filter device having a narrow (about 50 nm) spectral transmission window, which can be electrically tuned across a large part of the optical spectrum. Sequential reading may also be achieved by using two or more light sources to cause different colors to become visible for the reader, particularly a camera.

In accordance with figure 4 a UV light source 40 and an IR light source 42 are arranged in a way that the surface of substrate 44 is illuminated. The substrate 44 comprises a first array 46 of marks which provide a visible response if they are illuminated with IR source 42. A second array of marks 48 is provided on substrate 44 which becomes visible when it is illuminated with UV source 40. Light source 42 and light source 40 are connected to a power supply 50 which is activated by PC 32.

The IR light source 42 and the UV light source 40 may be activated sequentially. Thereby, the respective marks and the codes they are representing become visible for the

camera 30.

Alternatively, there may be two or more different marks which respond to UV and/or IR marks in different colors. For example, there are UV inks which are widely used for marking products or letters with invisible markings and which respond in various colors, such as blue, green, red, yellow etc. If this type of inks is used, in addition to illuminating the surface of the substrate 44 by UV light source 40 and/or IR light source 41, the tray 34 comprising different filters may additionally be used to differentiate between the different colors responding to illumination.

The term "light source" in this context means any device which emits visible or invisible light in one or more frequencies. Such light sources include lamps with or without filters to define frequencies, laser-light, LED-light sources or any other device which emits light in a suitable frequency range to make a marking visible for a reader, such as a camera. The marking may be a positive mark, i.e. a dot, a bar or any other geometric form. Alternatively, the whole surface of a substrate may be provided with a specific color and the marks be covered to create an inverse array of information. The mark may be applied by non-impact printers, such as ink-jet printers to allow fast printing. However, depending on the label or product to be marked, desired marking speed and the number of marks to be applied, other marking or printing techniques, including impact printers may be applied. Particularly letter-press, gravure, lithography or screen-printing techniques may be used.

The nature of the present invention implies a large number of different possible embodiments; for this reason it is intended that the foregoing description and the accompanying drawings shall be interpreted as only illustrative of the invention defined by the following claims.

Claims

1. A product marking comprising
at least one two-dimensional code of a first color, comprising a two-dimensional array of marks of said first color arranged to represent information according to an encoding algorithm, and
at least one mark or array of marks in a second color, arranged to represent additional information.

2. The marking of claim 1, wherein the second array is a two-dimensional code.

3. The marking of claim 1 or 2, wherein said codes are in alignment with one another.

4. The marking of claims 1 to 3, wherein the first and second colors do not substantially interfere in at least one spectral region.

5. The marking of claims 1 to 4, wherein the second color is in the invisible spectrum.

6. The marking of claims 1 to 5, comprising at least one mark or array of marks having luminescent properties.

7. The marking of claims 1 to 6, comprising at least one mark or array of marks having magnetic and/or magneto-optical properties.

8. The marking of claims 1 to 7, wherein each of the colors is applied as an ink imprint by an ink jet printer.

9. An apparatus for reading a product marking comprising arrays or marks of different colors, said apparatus comprising

15. A method of reading a product marking according to one of the claims 1 to 8, having arrays or marks of different colors, said method comprising the steps of:

- illuminating the marking by one or more light sources,
- optically distinguishing between differently colored marks of said marking (from one another),

- sequentially reading the marks of different color by a camera wherein the camera transforms the reading into electronic signals,

- supplying said signals to a computer and reading and de-coding said signals in said computer.

16. Method of marking a product comprising the step of applying at least one two-dimensional code in a first color, comprising a two-dimensional array of marks of said first color arranged to represent information according to an encoded algorithm, and
at least one mark or array of marks in a second color, arranged to represent additional information.

a camera,

a computer for reading and decoding information received from the camera,

a light source for illuminating the code, and

means for optically distinguishing the differently colored markings from one another.

10. An apparatus according to claim 9 wherein the means for optically distinguishing different colors comprise optical filters and/or light sources emitting light of different frequencies.

11. An apparatus according to claim 10 wherein the filters are capable of being positioned preferably in the optical path between the camera and the code.

12. An apparatus according to claim 10 wherein the filters can be positioned sequentially to read markings of different colors sequentially.

13. An apparatus according to claims 9 to 12 wherein the light sources are capable of being activated sequentially.

14. The apparatus of claims 9 to 13, wherein the distinguishing means comprise a plurality of filters, each adapted to pass light from only a respective one of said dot arrays,

a filter tray supporting the filters so that only one of the filters can be moved at a time between the camera and the code,

an encoder for providing a signal to the computer representative of the tray position, and

a motor, controlled by the computer, for moving the tray such as to control the filter selection.

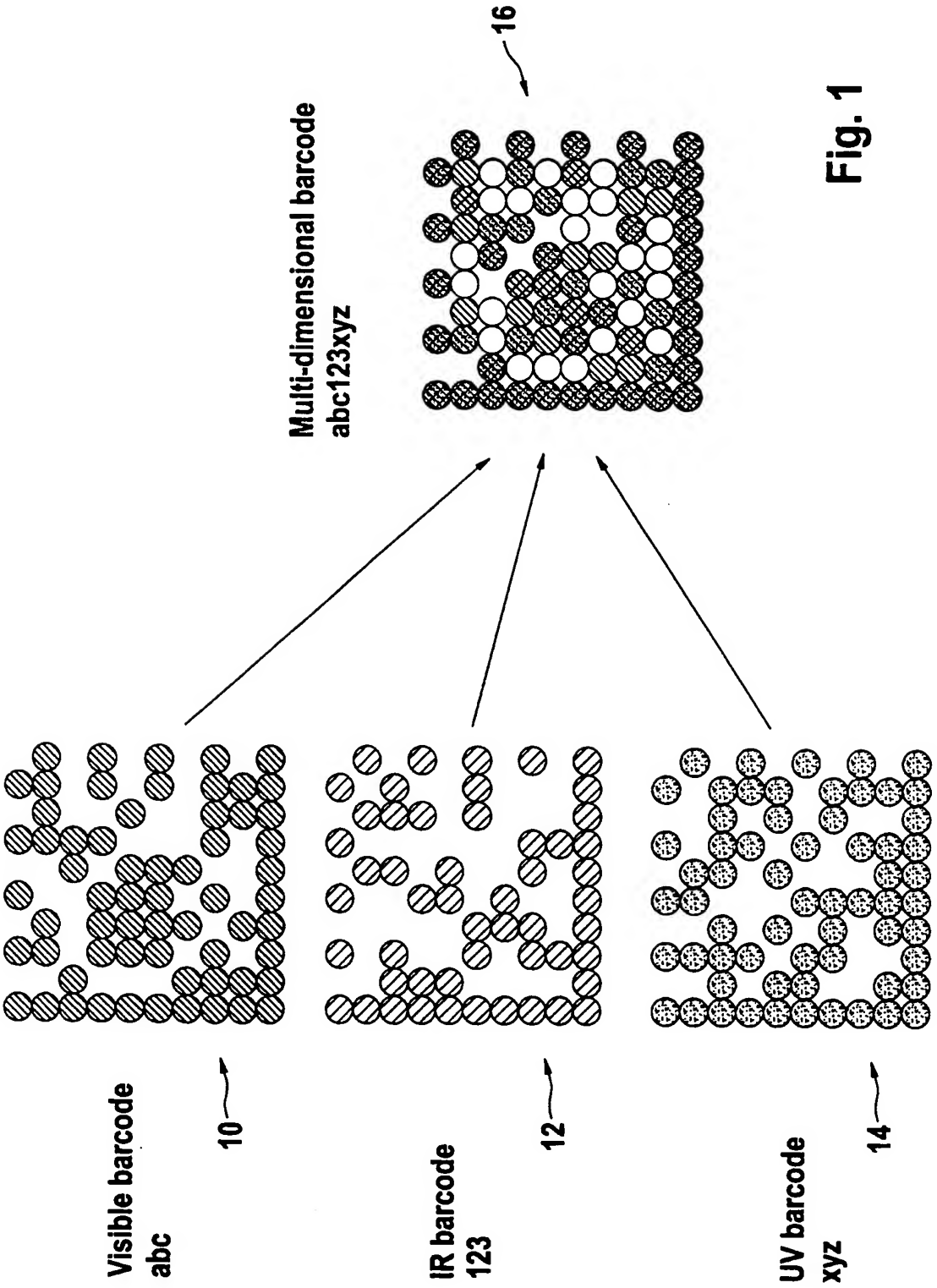

Fig. 1

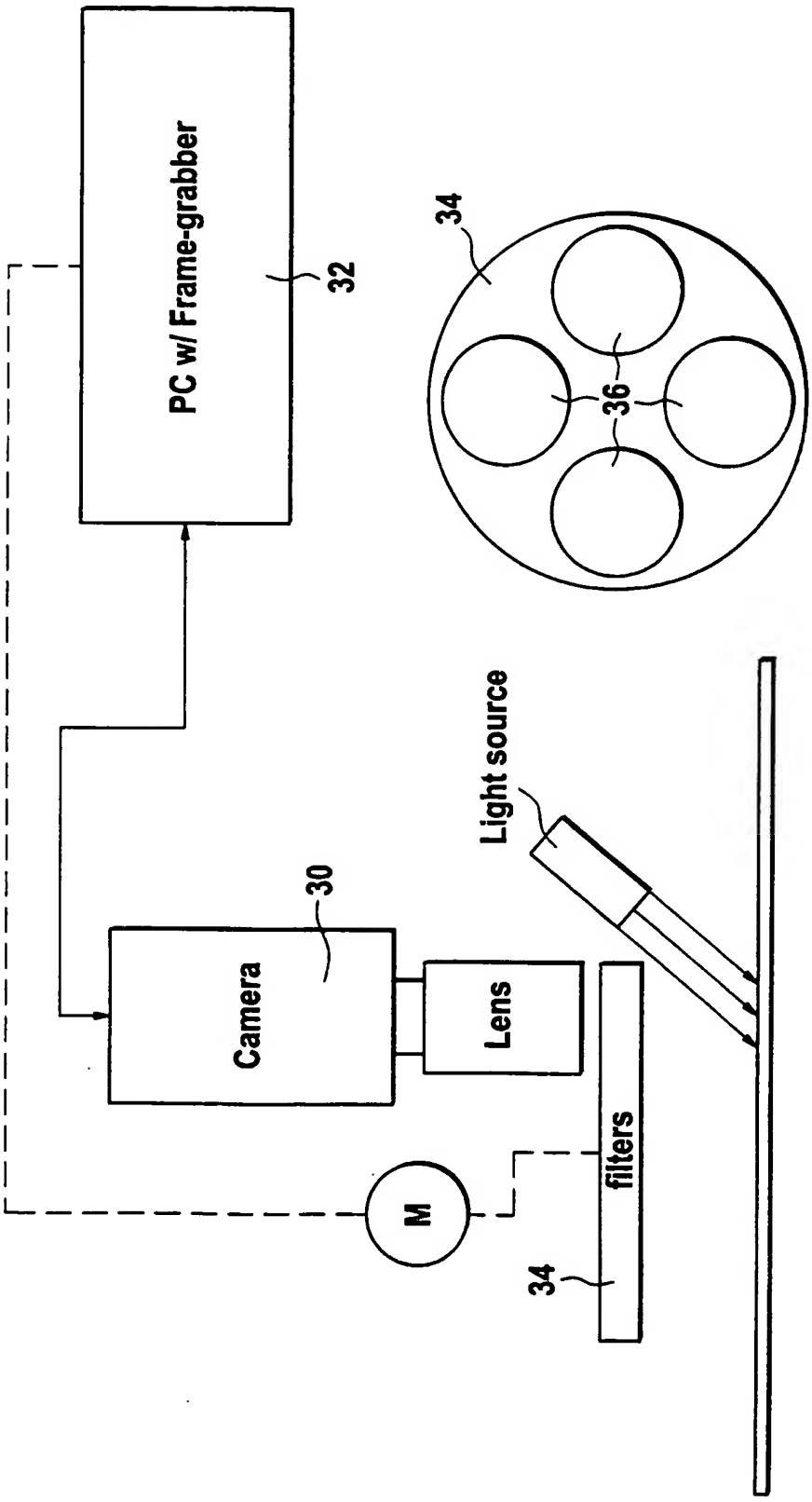

Fig. 3

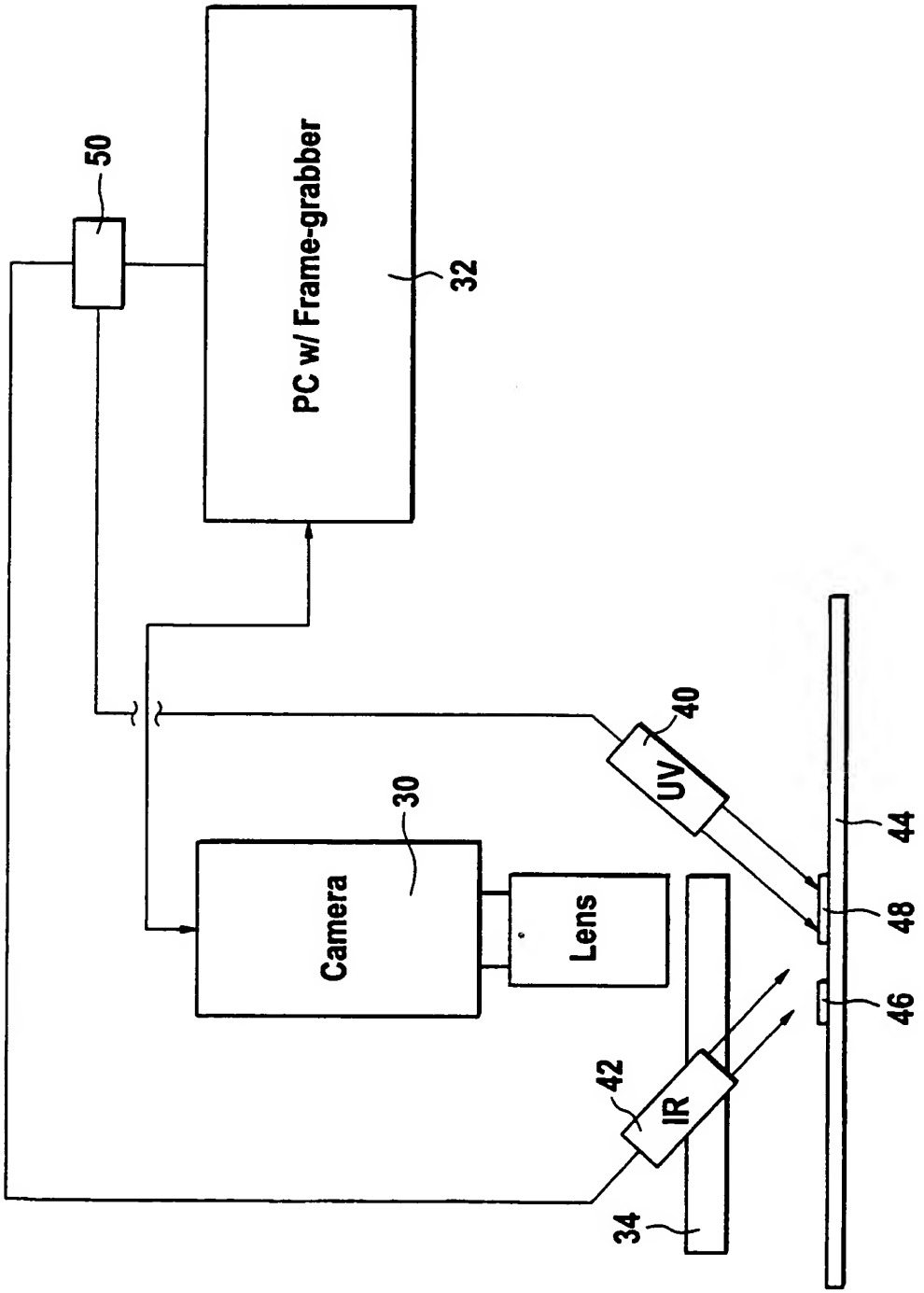

Fig. 4

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/CH 00/00472

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K19/06 G06K7/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, IBM-TDB, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 284 695 A (SECR DEFENCE) 14 June 1995 (1995-06-14) the whole document	1-16
X	WO 98 50882 A (INTERMEC TECHNOLOGIES CORP) 12 November 1998 (1998-11-12) the whole document	1-16
X	US 5 576 528 A (CHEW STEVEN M ET AL) 19 November 1996 (1996-11-19) the whole document	1-16

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
29 November 2000	06/12/2000

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

...ormation on patent family members

Inter nal Application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2284695 A	14-06-1995	NONE	
WO 9850882 A	12-11-1998	EP 0916123 A	19-05-1999
US 5576528 A	19-11-1996	NONE	